

Review

Current status of small bowel radiography

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Abstract

Background: In the past, small bowel examinations were usually ordered for the sake of “completeness.” As a result, small bowel radiography was performed casually and without attention to detail. This review examines pertinent clinical issues and the recent contribution of small bowel radiography to the evaluation and management of the patient with suspected small bowel disease. Recommendations for the clinical utilization of small bowel radiography are discussed.

Methods: Analysis of pertinent citations addressing valid indications for, and technique of, small bowel radiography from 1980 to July 1995 through a computerized bibliographic search (*Medline* and *Current Contents*).

Results: Accepted clinical indications for small bowel radiography include (1) unexplained gastrointestinal bleeding, (2) possible small bowel tumor, (3) small bowel obstruction, (4) Crohn disease, and (5) malabsorption. The current literature reflects the limitations of the conventional small bowel follow-through, various modifications to improve its clinical yield, the important contribution of enteroclysis in the workup, and subsequent management of patients with possible small bowel disease. A controversy in the radiology literature exists as to whether to use the small bowel follow-through or enteroclysis as the primary method of examining the small bowel.

Conclusion: The thoughtful selection of patients by clinicians for small bowel radiography is essential to make radiologic evaluation cost effective. The incidence of disease of the small intestine is low and is associated with nonspecific symptoms. Because of the inherent dif-

ficulty of visualizing numerous loops of an actively peristalsing bowel, a reliable imaging method is needed that not only detects small or early structural abnormality but also accurately documents normalcy. The yield of information provided by enteroclysis and its high negative predictive value suggests that it should be the primary method for small bowel examination. The “overhead”-based conventional small bowel follow-through should be abandoned. The “fluoroscopy”-based small bowel follow-through augmented when necessary by the peroral pneumocolon or the gas-enhanced double-contrast follow-through method is an acceptable alternative when enteroclysis is not possible.

Key words: Small intestine, radiography—Intestine, diagnosis—Small intestine, diseases.

The indications for ordering diagnostic procedures are undergoing intense scrutiny because of the need to control health care costs without compromising a high standard of patient care. Radiologic services are now evaluated by criteria that assess whether the use of a particular diagnostic method influences clinical management, improves patients' outcomes, and lowers medical care costs [1, 2]. The strengths and limitations of alternative imaging approaches must be well understood by both radiologists and clinicians to achieve the goal of providing the most appropriate method of examination to facilitate clinical management at minimal cost.

In many clinical situations, endoscopy has replaced barium examination as the primary means of assessing the mucosa of the upper gastrointestinal (GI) tract and the colon. Barium examination, however, still retains primary responsibility in the evaluation of the small in-

testine because of the limitations of enteroscopy (availability and thoroughness).

Although the small bowel (SB) represents 75% of the length and 90% of the mucosal surface of the alimentary tract, the incidence of SB disease is low. Symptoms of SB disease can be mimicked by disease of other organs, thereby making a definitive diagnosis difficult. An accurate radiologic examination to exclude disease definitely can be as important in the workup of patients with suspected SB disease as defining an SB abnormality. Clinically effective imaging of the SB should, therefore, not only be able to diagnose small or early structural abnormality but also must reliably document morphologic normalcy [3, 4]. Detailed barium evaluation of the small bowel is more difficult than examination of the upper GI tract or colon because of the problems caused by multiple overlapping loops crowded together within a limited space. Active bowel peristalsis exacerbates this problem.

This review examines the clinical issues that affect the relevance and yield of SB radiography in the diagnosis and management of SB diseases. Recommendations for the clinical utilization of SB radiography are discussed.

Materials and Methods

A search of computerized bibliographic databases (*Medline* and *Current Contents*) and analysis of pertinent citations from 1980 to July 1995 were done. Articles that addressed valid clinical indications for SB radiography (unexplained gastrointestinal bleeding, SB tumors, SB obstruction, Crohn disease, and malabsorption) and technique of SB radiography were included.

Results

Pertinent citations were chosen from the radiologic, gastroenterologic, endoscopic, and general surgical literature. Relevant articles in the current literature are discussed for each of the accepted clinical indications for SB radiography.

Unexplained or Obscure Gastrointestinal Bleeding

Gastrointestinal bleeding is defined as obscure or unexplained if diagnostic examinations of the upper GI tract and colon (including endoscopy, barium examinations, or both) fail to reveal the site and cause of bleeding. It is now established that endoscopy should be the first line of investigation used in the evaluation of acute and chronic GI bleeding. Nevertheless, unexplained GI bleeding remains a significant management problem. Even with current imaging advances and endoscopy, it appears that up to 50% of cases of occult GI bleeding

remain undiagnosed, and of those who undergo empiric surgery, one-third to one-half will bleed again [5]. Recent enteroscopic articles suggest that the major shortcoming of SB barium radiography is false-negative examinations [6, 7]. Most of these barium examinations were performed by using the conventional SB follow-through (SBFT).

Radiologic citations that addressed the issue of occult GI bleeding all involved the use of enteroclysis [8–15]. Enteroclysis was first suggested in 1985 as a method better than the SBFT for decreasing false-negative barium examinations [8]. This report described the value of enteroclysis for detecting surgically confirmed lesions of the SB responsible for the bleeding that had been missed by one or more preceding SBFTs (Fig. 1). Rex et al. subsequently showed that the diagnostic yield of enteroclysis in patients with unexplained GI bleeding was about 10% [9]. A more recent report by Moch et al. [10] corroborated these prior reports. In their series, 21% of 128 patients had confirmed or highly probable lesions seen at enteroclysis, which were considered to be the cause of obscure GI bleeding; 17 (13%) were found to have SB tumors, and three (2%) had jejunal arteriovenous malformations (AVMs). Their data suggest that, if enteroclysis fails to demonstrate a lesion as the likely source of bleeding, an AVM is the probable cause, and enteroscopy may then be required for diagnosis and treatment of these vascular malformations. The probability of an AVM increases in older patients with unexplained bleeding but who are otherwise asymptomatic. Herlinger et al. have demonstrated an AVM by enteroclysis [11]. The reliability of enteroclysis for this diagnosis appears to be poor because of the small size and pliability of the lesion. SB varices are also difficult to detect; however, they have been diagnosed by enteroclysis in two reports [14, 15]. For the diagnosis of Meckel's diverticulum, enteroclysis has been shown to be a better method of examination than the SBFT [16, 17]. Meckel's diverticulum is an uncommon but important cause of unexplained bleeding in the adult and a difficult condition to diagnose preoperatively.

Small Bowel Tumors

SB tumors most commonly present as undiagnosed GI bleeding, abdominal pain, or symptoms of SB obstruction (SBO). Despite major advances, both in surgery and diagnostic imaging in the last 40 years, the survival of patients with primary malignancies of the small intestine has not shown a parallel improvement. One reason for this is the advanced stage of the tumor at the time of surgery. In a recent study, the records of all patients with SB malignancy diagnosed over a 21-year period were analyzed [18]. The time from onset of symptoms to the first medical

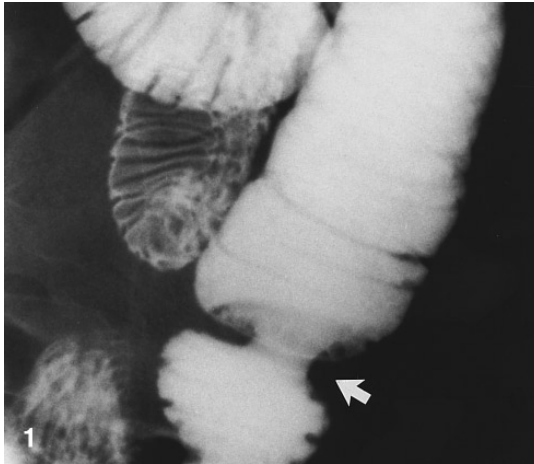


Fig. 1. *Nonsteroidal anti-inflammatory enteropathy.* Compression radiograph shows single-contrast phase of an enteroclysis of an elderly male referred for workup of occult GI bleeding. A focal circumferential narrowing without an associated mass was seen in the jejunum (arrow). A prior conventional SBFT was reported as negative. Because of the history of chronic intake of a nonsteroidal anti-inflammatory agent for arthritis, a secondary ulcer with edema was diagnosed. This was confirmed at surgery performed to exclude malignancy.

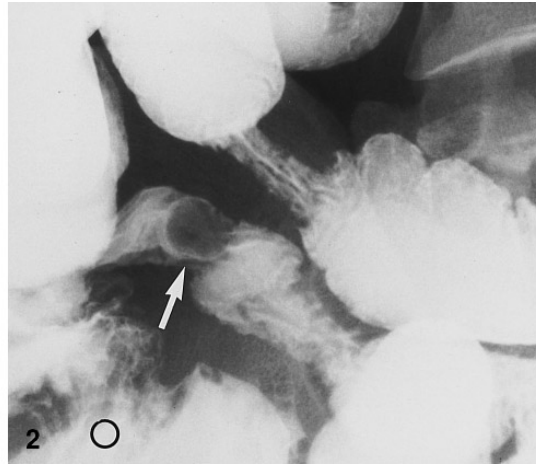


Fig. 2. *Small carcinoid in distal ileum.* Enteroclysis compression radiograph of distal ileum shows a small (10 mm) intramural polypoid mass in the terminal ileum (arrow) of a middle-aged female with undiagnosed lower GI bleeding. All prior investigations were non-revealing. Surgery confirmed presence of a polypoid mass. Histology showed carcinoid. There were no nodes involved. Circle indicates the cecum.

contact and the time from medical contact until diagnosis was evaluated in 77 patients. The average delay in diagnosis attributable to the patient failing to report symptoms was less than 2 months, to the physician failing to order the appropriate diagnostic test was 8.2 months, and to the radiologist failing to make the diagnosis was 12 months. Thus, the major delay in making the diagnosis of a SB tumor was after medical help had been sought by the patient. Radiologic misinterpretation or false-negative examination accounted for the longest delay. In this series, three-fourths of the patients had advanced disease at the time of diagnosis.

A retrospective review of 40 malignant tumors seen in one Japanese institution over 14 years has reported that barium studies detected 20 of 24 tumors in patients who underwent SB radiography. Computed tomography and ultrasonography were less sensitive for jejunal tumors (17% and 31%, respectively) than for duodenal tumors (100% and 50%, respectively) or ileal tumors (70% and 73%, respectively) [19]. An American report compared enteroclysis and the conventional follow-through in the demonstration of primary malignant tumors of the small intestine [20]. Of 71 patients diagnosed with primary mesenteric malignant tumors in the SB, SBFT had a sensitivity of 61% and enteroclysis a sensitivity of 95%. The actual tumor was shown in only 33% of SBFTs, whereas it was shown in 90% of enteroclyses. This finding is similar to that of a prior report that showed that the SBFT had a sensitivity of 44% for actual tumor demonstration [21]. These studies indicate

that enteroclysis is far more sensitive than the SBFT for the detection of SB cancers. Whether enteroclysis can diagnose early-stage tumors that will affect prognosis remains to be seen (Fig. 2). The double-contrast technique has been shown to depict accurately the morphological changes of primary small intestinal lymphoma in a series of 20 primary intestinal lymphomas of the "western" type reported from Japan [22].

A European study of 18 patients with surgically confirmed benign tumors diagnosed over a period of 7 years by enteroclysis reported that the average time lapse from the onset of symptoms to diagnosis was 16 months (range = 1 month to 7 years) [23]. Most of these tumors were leiomyomas, adenomas, or hamartomas. The investigators claimed a high degree of preoperative differentiation of tumor type, although they frequently missed ulceration. They suggested that enteroclysis is an effective means for evaluating patients with unexplained abdominal symptoms when the possibility of a benign SB tumor is a clinical consideration.

Small Bowel Obstruction

The SB is involved in 60–80% of cases of intestinal obstruction. Despite being one of the most common surgical abdominal emergencies, SBO is still frequently misdiagnosed. Avoidable morbidity and mortality from intestinal obstruction continue to be significant problems and are chiefly related to delays in diagnosis.

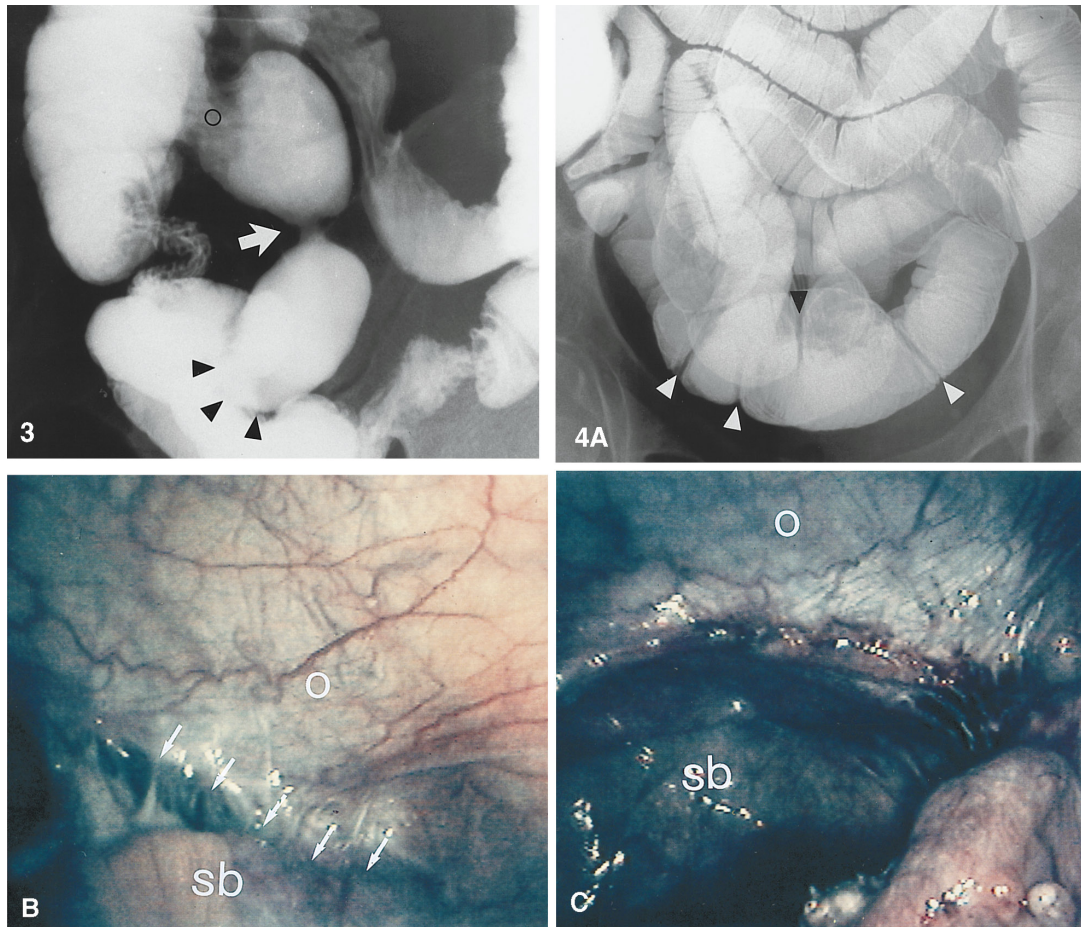


Fig. 3. Diagnosis by enteroclysis of a mesodiverticular band and Meckel's diverticulum in a middle-aged male with recurrent unexplained abdominal pain over many years and unrevealing PARs. Single-contrast phase of an enteroclysis shows a long diverticulum in the distal ileum with a circumferential defect in its midportion (*arrow*). *Arrowheads* delineate the fundus of the diverticulum. Demonstration of the typical junctional fold pattern (O) suggests the diagnosis of a Meckel's diverticulum [16]. At surgery, a Meckel's diverticulum was found. The diverticulum was attached at its midportion (*arrow*) by a fibrous cord (consistent with a mesodiverticular band) to the lower anterior abdominal wall. The band most likely was the fulcrum of a recurrent SB volvulus. The patient has since been asymptomatic (reproduced with permission [41]).

Fig. 4. Diffuse nonobstructive pelvic adhesions released by laparoscopic surgery—preoperative diagnosis by enteroclysis. **A** Radiograph shows

pelvic segments of ileum during double-contrast phase of enteroclysis of a middle-aged woman with a history of prior hysterectomy who presented with unexplained recurrent abdominal pain. Prior PAR and abdominal CT were unrevealing. The pelvic segments of ileum were not movable by using angled (cephalad) compression during fluoroscopy done in the single-contrast phase of the study. Note scattered areas of peritoneal adhesions manifested by multiple linear defects (*arrowheads*) secondary to adhesive band fixation. **B** Print obtained during laparoscopy shows SB (*sb*) fixed to vaginal cuff and posterior wall of urinary bladder (*arrows*) by multiple adhesions (O, urinary bladder). **C** Following laparoscopic lysis of adhesions, the SB has dropped away from the vaginal cuff and urinary bladder. The cul-de-sac can now be seen. The ovaries and Fallopian tube are seen to the right of the SB (courtesy of Earle U. Robinson, Jr., M.D., Department of Gynecology, Methodist Hospital of Indiana).

Plain abdominal radiography is diagnostic in most cases of intestinal obstruction and remains the mainstay in the evaluation of suspected SBO. However, diagnostic failures occur in approximately one-third of cases, often because plain abdominal radiography fails to demonstrate convincingly the presence of SBO [24]. Additional imaging is therefore needed to confirm or exclude the diagnosis or when management of the patient re-

quires more accurate localization and characterization of the obstructing process (Fig. 3).

In recent years, there have been a number of articles encouraging the use of computed tomography (CT) instead of barium examination for the diagnosis of SBO [25–29]. In most of these publications, the role of the SBFT, which is too frequently employed in the diagnosis of SBO, has been questioned. Even when done meticu-

lously, the SBFT has been shown to have inherent limitations due to its inability to test distensibility and fixation [30–32]. In contrast, enteroclysis has been shown to be of value in defining distensibility and fixation [33–35]. These features have allowed the accurate diagnosis and localization of partially or nonobstructing adhesions causing unexplained abdominal pain. Enteroclysis has also been shown to be of value in determining the number and extent of adhesive obstructions and in differentiating between obstruction secondary to metastatic disease or adhesion [36]. In one recent study published in a gastroenterology journal, enteroclysis correctly predicted the presence of obstruction in 100%, the absence of obstruction in 80%, the level of obstruction in 89%, and the etiology of obstruction in 86% of operated patients [24]. Several clinical reports attest to the contribution of enteroclysis in the management of SBO [37–40].

The issue of whether to use CT or barium examination in the workup of patients with possible intestinal obstruction was addressed in a recent review [41]. This review suggested a pragmatic radiologic approach based on the interpretation of plain abdominal radiographs and the clinical background of each patient.

First, if plain abdominal radiography (PAR) is normal or abnormal but nonspecific in a patient with a history compatible with intermittent SBO, enteroclysis is the imaging method of choice. A recent analysis of patients with the so-called abnormal but nonspecific plain films showed that 22% had varying degrees of obstruction [24]. Important benefits of enteroclysis in this category is the reliable exclusion of lower grades of partial obstruction and the selection of symptomatic patients who might benefit from laparoscopic lysis of adhesions (Fig. 4).

Second, if PAR shows probable SBO, additional imaging depends on clinical circumstances. (1) CT is the procedure of choice if the patient has fever, tachycardia, localized abdominal pain, or leucocytosis because of its ability to recognize abscess, other acute inflammatory processes, and mesenteric ischemia. (2) If the clinical history suggests simple mechanical obstruction, enteroclysis is appropriate. Its high accuracy in confirming or excluding the diagnosis, assessing the severity, and defining the etiology of partial obstruction makes it important in the choice of whether to operate or continue nonsurgical management.

Third, if PAR reveals unequivocal SBO, multiple factors influence the selection of imaging procedures. (1) If high-grade or complete SBO is noted on PAR, early surgical evaluation of the patient is important because such patients are at increased risk for strangulation. The need for urgent operation will contraindicate further diagnostic imaging. (2) In patients with a history of malignancy, CT and enteroclysis may be complementary. Enteroclysis can be accurate in distinguishing adhesions from metastases, tumor recurrence, and ra-

diation damage [36]. (3) In an elderly, frail patient with abdominal pain and distention whose plain films show SBO, CT appears to be appropriate. In this group of patients, the SBO pattern may be caused by a colonic obstruction (carcinoma or diverticulitis), mesenteric insufficiency, an incarcerated hernia, or appendicitis. In such patients, CT provides a method of expeditiously determining the cause of obstruction compared with the more time-consuming enteroclysis study.

Fourth, if PAR shows colonic distention and diffuse gaseous dilatation of the small intestine, adynamic ileus or colonic obstruction may be difficult to distinguish from partial SBO. The approach to additional imaging is modified by several factors. (1) If nonobstructive colonic ileus or colonic obstruction with an incompetent ileocecal valve is suspected, a barium enema is an inexpensive and fast method to rule out colonic obstruction and confirm the diagnosis of colonic ileus. (2) In patients with fever or leucocytosis with localized abdominal pain or in postoperative patients, CT, with its ability to demonstrate intraabdominal abscess, is the suggested imaging method. Patients who are likely to have difficulty in tolerating a barium enema should be included in this group. The value of CT in the postoperative patient to distinguish between ileus and mechanical SBO has recently been confirmed by Frager et al. [42].

A carefully taken history, physical examination, and properly interpreted plain films will continue to be mainstays in the workup of suspected SBO. Current radiologic techniques offer clinicians more sensitive methods of diagnosing and predicting the etiology of obstruction. More importantly, it may increase the probability that the decision to manage a patient medically or surgically will be correct. Recently, the dictum that acute intestinal obstruction should be treated by early operation has been challenged [43]. The judicious use of these modern techniques can reduce the possibility of missed strangulation and allow a longer period of nonoperative management in postoperative adhesive SBO. The old surgical adage, “never let the sun set or rise on bowel obstruction,” based on the inability of clinical and laboratory examination to predict reliably the presence of strangulation, can be relegated to surgical archives. The appropriate use of CT may allow precise diagnosis of strangulated obstruction [44].

Crohn Disease

One of the most important indications for SB barium studies is suspected Crohn disease. Clinical studies have shown that the delay between onset of symptoms and the diagnosis of Crohn disease is greatest when the disease is limited to the small intestine. The National Cooperative Crohn’s Disease Study reported an average

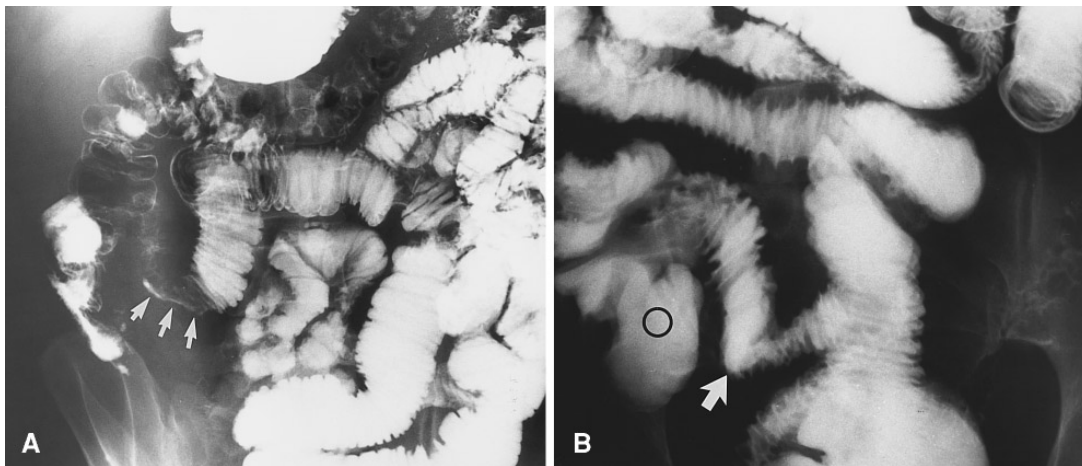


Fig. 5. *SBFT and enteroclysis in the management of SB Crohn disease.* **A** Delayed radiograph (90 min) of SBFT shows a long segment of narrowing (*arrows*) that is suggestive of a long stricture in the distal SB in a patient with a history of Crohn disease now presenting with SBO. SB dilatation proximal to the narrowed segment is consistent with obstruction secondary to the stricture. Surgery was considered.

B Preoperative enteroclysis to define extent of disease done 5 days after SBFT shows long segments of moderate fold and wall thickening of the distal ileum but no evidence of a stricture. Abrupt angulation (*arrow*) and fixation of the distal ileum suggests peritoneal adhesions. Nonsurgical management was continued with satisfactory result. Circle indicates the cecum (reproduced with permission [47]).

lag time of 36 months (from onset of symptoms to time of diagnosis) for SB Crohn disease [45]. The prospective accuracy and clinical relevance of enteroclysis in suspected Crohn disease of the small intestine was recently reported [46]. Prospective interpretation showed that the technique is extremely accurate with a sensitivity, specificity, and accuracy of 100%, 98.3%, and 99.3%, respectively. Thirty-one percent of the patients had lesions of mild Crohn disease. Clinical evidence of Crohn disease did not develop in the patients in whom enteroclysis revealed no abnormality in 2 or more years of clinical follow-up. Enteroclysis also provides detailed structural information relevant to appropriate management of the disease.

In patients with known Crohn disease who presented with symptoms and PAR findings of SBO the investigators highlighted the radiological distinction between luminal narrowing caused by potentially reversible edema and/or spasm and narrowing due to fibrosis because of its importance in treatment decisions (Fig. 5) [47]. Other reports have supported the superiority of enteroclysis in the diagnosis of Crohn disease [48–55]. Enteroclysis has been shown to be superior to the SBFT in the demonstration of sinus tracts and fistulae and in defining the extent of the disease, an important consideration when surgery is planned [50–55]. Other investigators have shown the high accuracy of a well-performed SBFT in the diagnosis of SB Crohn disease [56–58]. The severity of the disease and a long-term follow-up of the negative examinations, however, were not reported in the latter citations. A more recent European review of a large group of patients (1465), many

of whom had Crohn disease, also showed a high sensitivity (93%) and specificity (97%) of enteroclysis [59].

There is still debate about the best method for evaluating the SB radiologically to make (or exclude) the diagnosis of Crohn disease. Pertinent citations appear to reflect local demands by clinicians and available expertise. Most citations, however, favor enteroclysis as being able to give more detailed and reliable information that influences management [47]. A detailed (fluoroscopy-based) SB follow-through, augmented if necessary by additional methods to demonstrate the distal ileum, appears adequate in the initial assessment of possible SB Crohn disease [60–62].

Malabsorption

The recognition of a malabsorption state is based on clinical evaluation and biochemical tests. The task of the radiologist is not to establish the diagnosis of malabsorption; it is to demonstrate the site and/or etiology of malabsorption and demonstrate any concomitant complications. Barium studies remain the predominant radiologic tool for this purpose (supplemented by other imaging methods when indicated). The findings of malabsorption on SBFT (flocculation and segmentation of barium, thickening of mucosal folds, and dilatation of intestinal loops) are nonspecific [63]. Enteroclysis is the preferred barium technique in malabsorption states because it avoids or delays flocculation of the barium suspension, which is responsible for many of the artifactual appearances seen with SBFT [64]. Frequently encoun-

tered malabsorption-related diseases, namely celiac disease and bacterial overgrowth syndromes, were highlighted in a recent review by Herlinger [64]. The classic clinical presentation of adult celiac disease is seen in fewer than half of the patients. Vitamin deficiencies, anemia, vague abdominal pain, weight loss, and neurologic disorders may be among the nonspecific findings in some patients with latent celiac disease in whom a number of events can induce the onset of such symptomatology. In active celiac disease, enteroclysis demonstrates a reversal of the normal fold pattern in the jejunum and ileum that is specific for the diagnosis, i.e., reduced jejunal and increased ileal folds [65]. In 80% of patients with celiac disease, enteroclysis demonstrates three or fewer folds over a length of 2.5 cm of a moderately distended proximal jejunum and, in the majority, four to six folds over a 2.5-cm length in the distal ileum. Although this reversal of the jejunoileal fold pattern has been described with the SBFT in longstanding nontropical sprue [66], the seminal article by Herlinger and Maglinte [67] has established the fold counts of the normal jejunum and ileum, which has not been described previously and which can suggest the diagnosis of early celiac disease, especially in those with atypical presentation (Fig. 6). The fold changes in subtle cases were better appreciated during the methylcellulose double-contrast phase of the enteroclysis. Their findings have been replicated by other reports [68, 69]. A recent article using a single-contrast technique reported a sensitivity of 40% [59].

In patients who present with clinical features of malabsorption and a possible diagnosis of celiac disease, characteristic histology of biopsies taken from the jejunum or duodenum is usually considered sufficient clinical indication for prescribing lifelong adherence to an unpleasant diet [65]. In view of this, enteroclysis becomes relevant to the diagnosis and management of patients with celiac disease in the following circumstances: (1) patients with atypical presentations; (2) patients in whom the biopsy is consistent with celiac disease, but the differentiation from other disorders with similar histology is indicated (e.g., bacterial overgrowth syndrome, giardiasis, Zollinger-Ellison syndrome, and eosinophilic gastroenteritis); (3) the occasional unmasking of cases of clinically unsuspected celiac disease in whom there may be villous atrophy; (4) the assessment of patients who do not consistently adhere to the prescribed diet; enteroclysis can show features of celiac disease modified by the intermittent dieting and can demonstrate a coexisting disorder; (5) because atypical celiac disease can become evident if malignant complications develop, enteroclysis in such patients can demonstrate both the primary disease and the malignancy (whether lymphoma or carcinoma); (6) in patients with known celiac disease who have done well and remain com-

pliant but in whom recurrence of celiac activity mandates enteroclysis to identify possible complicating malignancy or ulcerative jejunoileitis (Fig. 7); and (7) rare cases of patients with unresponsive celiac disease who may be on a relentlessly downhill course, have atrophic mucosa, and on enteroclysis show total absence of folds in the proximal jejunum and occasionally mesenteric lymph node cavitation [70].

In patients with bacterial overgrowth syndromes, enteroclysis has been shown to demonstrate structural abnormalities that predispose to bacterial overgrowth (e.g., jejunal diverticulosis, blind loops, and bowel segments above strictures) or abnormal peristaltic function (pseudoobstruction, scleroderma amyloidosis, and diabetes) [71–73]. In a separate group of patients who may present with a micronodular mucosal surface pattern (Whipple's disease, microbacterial infection in AIDS, lymphangiectasia, macroglobulopathy, and amyloidosis), the value of enteroclysis for the diagnosis of these diseases has been shown [65].

Comments

Experience has shown that enteroclysis is preferred in ill and/or frail elderly patients because it requires little patient cooperation and can be completed during one table sitting [62]. The conventional SBFT examination can be difficult to perform in this group of patients: they have difficulty ingesting a diagnostic quantity of barium, and transit time is often prolonged, requiring many patient transfers on and off the X-ray table and a lengthy exhausting stay in the department. Moreover, the SBFT is often nondiagnostic or clinically inconclusive. In other situations, particularly in the assessment of SB Crohn disease, the technique of SB radiography has been the subject of controversy [74, 75].

When it is important to document the detailed mucosal anatomy of the SB, enteroclysis depicts measurable, definable parameters, e.g. the number of folds per unit length, thickness and height of folds, diameter of the lumen, and thickness of the bowel wall, better than the SBFT [3]. The shape of the folds and alterations of the mucosal surface pattern are also well demonstrated. Objective quantitative data are far more informative to the clinician rather than a statement that the SB mucosa is irregular, bizarre appearing, or probably normal (Fig. 8) [4].

Clinicians must rely on a good quality SB study to find subtle disease or exclude its presence beyond the range of the endoscope to define fully the extent of known disease and to distinguish between caliber changes due to edema and fibrosis because of its importance in treatment decisions. A false-negative SBFT deflects the workup away from the SB, wasting time and money in making the diagnosis. Delays in diagnosis

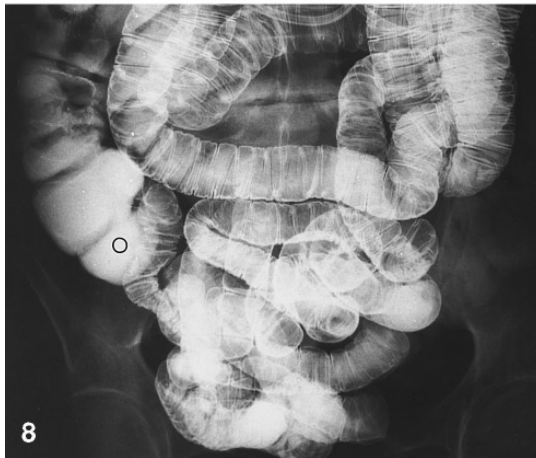
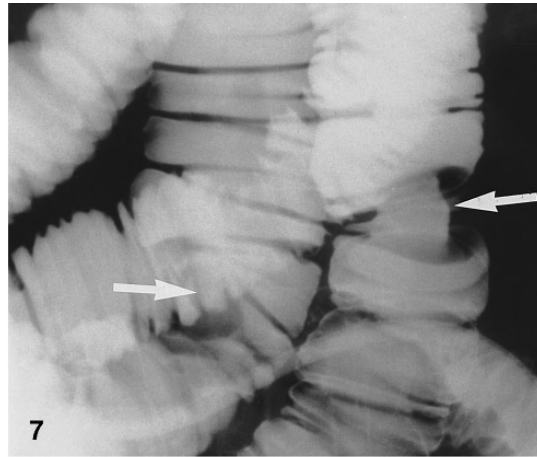
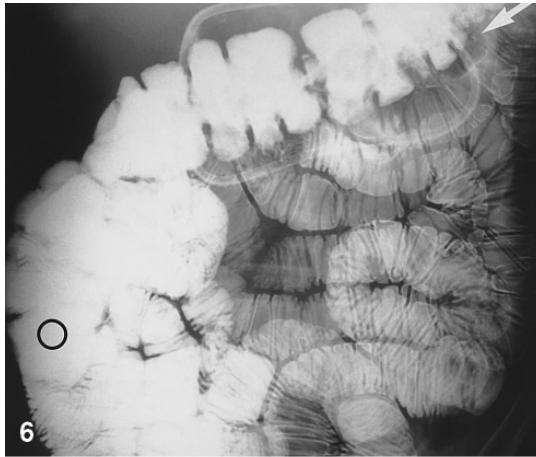


Fig. 6. *Enteroclysis in atypical sprue.* The examination was performed on an elderly man who presented with vague abdominal pain and unexplained anemia. Enteroclysis shows an appreciable decrease in the number of folds in the jejunum and an increase in the ileum and a reversal of the normal SB fold count. Perendoscopic biopsy confirmed the diagnosis of sprue. Circle indicates the cecum. Arrow points to balloon of enteroclysis catheter proximal to the ligament of Treitz. Note beginning dilution of contrast in proximal jejunum.

Fig. 7. *Enteroclysis in the diagnosis of malignancy complicating sprue.* Enteroclysis was done on a patient with known sprue who was compliant to diet but with increasing celiac disease activity. Two nonobstructing eccentric masses (arrows) are seen in the jejunum, where a decrease in the number of folds is apparent. The lesions were confirmed at surgery. Histologic sections showed T-cell immunoblastic lymphoma.

Fig. 8. *Normal small bowel.* Enteroclysis confidently demonstrates measurable parameters, indicating normality of all segments of the mesenteric small intestine. Reliable demonstration of normality has been inconsistent with the SBFT. Circle indicates the cecum.

may alter outcome and should be minimized whenever possible. In almost all reports, enteroclysis yields the maximum amount of important anatomical information that is important for clinical decision making. A prospective comparative study has shown the superiority of enteroclysis even when the follow-through is done with large amounts of barium and frequent fluoroscopy [76].

A meticulously conducted (fluoroscopy-based) oral barium examination of the SB has been shown to be an acceptable alternative, particularly in the assessment of Crohn disease [56–58]. The gas-enhanced follow-through and the peroral pneumocolon techniques have improved visualization of the distal SB [60, 61, 77–79]. The use of hypotonic agents has also been shown to improve visualization of the distal SB [80, 81]. The fluoroscopy-based method of SB examination augmented by other techniques to demonstrate the distal SB should be distinguished from the conventional SB follow-through, which is an “overhead”-based serial radiographic examination with limited fluoroscopy. The latter method results in a cascade of additional imaging studies because of its inaccuracy [31, 48]. Performing additional tests increases the cost of making a firm di-

agnosis and, by delaying appropriate therapy, may adversely affect prognosis. In 1982, we recommended that this method of SB examination be abandoned [82], and the plea was reiterated in 1987 [62]. Experience has shown that enteroclysis overcomes most of the limitations of the follow-through. In almost all of the recent citations, enteroclysis has yielded the maximum amount of clinically important anatomical information. Although the follow-through is still the most frequently used method of examining the SB, it appears that more radiologists are performing enteroclysis. The issue of whether to use enteroclysis or a “dedicated” SB follow-through as the primary method of examination will become relevant in the current health care environment. Demands by clinicians and local radiologic expertise will likely dictate the method of SB examination.

Paramount to this discussion is a careful selection of patients by knowledgeable clinicians as to which need SB radiography. Enteroclysis is a procedure that is more expensive than the SBFT and involves more radiation to the patient. Those with a low clinical suspicion of SB disease should probably not undergo SB radiography. Those with high clinical suspicion of SB disease demand the most

accurate technique locally available. It appears that, in the workup of patients for suspected Crohn disease of the small intestine, a detailed follow-through augmented, if necessary, by techniques to improve visualization of the folds of the distal ileum appears acceptable. Specific management relevant queries in patients with established Crohn disease, however, are more reliably answered by enteroclysis.

Objections to enteroclysis because of poor patient tolerance appear to reflect the lack of skill of the radiologist and not the technique itself. Recent refinements in technique and the use of "conscious" sedation have made enteroclysis a well-tolerated and quick method of examining the SB [83]. In patients with SBO, use of a catheter designed to allow decompression has made it easier for patients who already have a nasogastric in place [84]. The tube is tolerated better than the Salem sump nasogastric tube by patients, and it can be positioned in the proximal jejunum without difficulty as opposed to other long tubes [85].

A recent overview has stated that either enteroclysis or the follow-through method is an acceptable investigation given valid clinical indications [86]. In this overview, it was stated that enteroclysis is mandatory when the SBFT findings are normal. This recommendation implies redundant procedures and increases cost and radiation exposure. Currently, external factors may not allow this approach. As cost containment becomes emphasized in medicine, there will be less approval for a "confirming" study or one seen as duplicative. If the SBFT is negative or inconclusive, insurance companies may disallow payment for another procedure. In health plans where duplicative or confirming studies are not reimbursed, the more accurate method should be used first as the primary method of examination. As long-term follow-up is reported, the high negative predictive value of enteroclysis validates its use as the primary screening examination for the assessment of possible SB disease [59, 86–88]. However, in departments where interest and expertise in enteroclysis are not available, the fluoroscopy-based follow-through with its modifications and not the overhead radiograph-based conventional examination still commonly done by radiologists appears to improve the sensitivity of the examination [60, 61]. The SBFT, as "conventionally" performed, has no role in the practice of cost-effective medicine. If it is negative, it does not exclude disease; if positive, a more specific examination is often required to confirm the findings. Similar to the SBFT, enteroclysis will have operator-dependent errors (perceptive, interpretive, and technical) that will diminish with experience. Enteroclysis, however, overcomes most of the inherent limitations of the oral method and is the more reliable method of SB examination.

The SB study is important in the management of patients with suspected SB disease [89]. The mesenteric

small intestine is a difficult organ to examine. Its assessment is somewhat analogous to that of separating out and identifying a large number of writhing snakes in a crowded reptile tank at the zoo. There are no shortcuts to achieve a reliable examination [3, 62]. Enteroscopy is still not a practical clinical tool at present. In the practice of cost-effective medicine, SB evaluation should start with careful patient selection and the application of methods of examination that can provide reliable evidence of normalcy and the diagnosis of early or subtle structural abnormalities and that can influence management decisions in patient care.

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